COMMUNITY SURVEY REPORT
ATD/RAF Airflow Analysis Needs

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ATD/RAF created a survey to identify community needs and interest related to airflow analysis for airborne sampling. The web-based survey was open between 17 Jan and 28 Feb 2003, and thirty-three responses were received. Of these, 16 were from U.S. universities, 12 were from NCAR (6 ACD, 3 MMM, and 3 ATD), 3 were from Germany or Great Britain, 1 from NOAA, and 1 was anonymous. Respondents were asked their primary expertise: 28% listed “atmospheric chemistry”, 28% “cloud physics” or “cloud chemistry”, 25% “atmospheric aerosols” or “air pollution”, 9% “radiation”, 6% “boundary layer” and the remainder “other”. The survey was divided into three sections, pertaining to HIAPER, the C-130, and more general issues.

HIAPER SECTION

97% of respondents were definite or possible users of instrumentation on HIAPER. Expected instrumentation use fell in the following categories (with some investigators planning to use more than one instrument type): gaseous chemistry, including H_2O (33%), aerosols (24%), clouds (17%), winds/state parameters (13%), radiation/remote sensing (7%) and the remainder other instruments. Likely mounting locations were upper or lower fuselage (44%), wingpod (30%), wing (12%), nose (10%), and tail (4%).

Desired research altitudes were fairly evenly divided: 38% expected to sample at mid-levels (10-30,000 ft), 35% at high-altitude, 30-50,000 ft, and 27% at low-altitude, 0-10,000 ft . These statistics reflect the wide range of scientific missions expected for HIAPER. Particles of all sizes and types were of interest to the respondents: aerosols < 1 μm (25%), aerosols > 1 μm (22%), cloud droplets (18%), ice crystals (17%), and drizzle and rain (18%). When asked the importance of particle size distributions to their measurements, 60% said they were of high importance, 13% of medium importance, and 23% of low or no importance.

Respondents were asked what information about HIAPER’s airflow characteristics is of most importance to them and were given some examples. Most cited the examples, such as particle trajectories, enhancements, and shadow zones (28%), flow speed and angles (28%), boundary layer thickness (26%), and pressure distributions (12%). Other concerns given were the possible effects of dynamic heating and exhaust ports on sampling.

67% of respondents expect to or might use an inlet for their HIAPER instrument. Requirements for inlets were variable. For example, expected flow rates vary from 1-2 L/min to 100 L/min. Some investigators are willing to share an inlet and would like ATD to provide it, while some have specific requirements for an inlet that would be dedicated to their instrument. Several would like to work on inlet development in conjunction with ATD. Flow modeling was

suggested not only determine characteristics of airflow around the aircraft itself, but for specific inlet issues such as “how particles behave around the inlet, particle amplification, shadowing, etc.”, and “avoidance of … particle shattering on structures immediately upstream of probe sample volume.”

Investigators were asked to describe possible measurement strategies for verifying model results. Many suggested making measurements with identical probes in different locations (22%), using a Rosemount 5-hole or other (micro-pitot) device for measuring flow characteristics at different locations (17%), maneuvers at different angles and speeds (9%), or tracer experiments (9%). Other ideas involved the trailing cone, laser velocity measurements, flybys, inlet tests, and column closure studies.

C-130 SECTION

81% of respondents were definite or possible users of instrumentation on the C-130. Expected instrumentation use fell in the following categories (with some investigators planning to use more than one instrument type): gaseous chemistry, including H_2O (41%), clouds (22%), aerosols (16%), winds/state parameters (16%), and radiation/remote sensing (6%). If these results turn out to be representative of the general community, HIAPER may have slightly fewer payloads related to gas-phase chemistry and clouds and slightly more related to aerosols than the C-130. 58% of all respondents said their sampling considerations for the C-130 are essentially the same as that for HIAPER. As a result, those HIAPER responses have been commingled with the information given below.

Likely mounting locations on the C-130 were the upper or lower fuselage (40%), wingpod (37%), wing (14%), and nose (9%). These locations are quite similar to HIAPER, but slightly less instrumentation is expected on the fuselage for the C-130 and slightly more on the pods. Desired research altitudes were evenly divided with 50% expecting to sample at low altitude (0-10,000 ft), and 50% at mid-levels (10-25,000 ft). Particles of interest were similar as for HIAPER: aerosols < 1 μm (23%), aerosols > 1 μm (20%), cloud droplets (19%), ice crystals (16%), and drizzle and rain (22%). When asked the importance of particle size distributions to their measurements, 52% said they were of high importance, 20% of medium importance, and 28% of low or no importance.

Airflow characteristics of most importance to respondents were similar to those given in the HIAPER section. A repeated additional concern (that would also apply to HIAPER) was potentially distorted streamlines and particle trajectories around wingpods that could affect measured cloud droplet distributions and cloud water chemistry. The need for verification of model results was again stressed, with suggested strategies for testing model results similar to those given in the HIAPER section. 71% of respondents expect to use an inlet for their C-130 instrument, with inlet requirements similar as for HIAPER.

OTHER ISSUES

About half (52%) of respondents would like to have airflow and/or particle trajectories analyzed for non-RAF instruments that they use. These were primarily gaseous chemistry, aerosol and cloud physics instruments and/or inlets. Of those who need airflow analyses, 17% said they would be interested in having this analysis performed by ATD on a chargeback basis, and 72% said they might be interested in such an arrangement.

When asked where they would like to have results of airflow analyses disseminated, 33% chose a website, 26% a technical note, 18% a journal publication, 16% to individual users as needed, and 7% by email.

24% of respondents had at least some experience with CFD software for airflow analysis, with the majority of these using the commercial software Fluent. Three of the seven Fluent users were from NCAR. Those familiar with Fluent felt it was a powerful and useful code, but "requires significant expertise to be used properly". One current user felt low on the learning curve and said, "We could use some help from folks with expertise to get the job done expeditiously".

Respondents were asked for any additional comments. One concern was that airflow analyses might be considered too costly by reviewers if included in proposal budgets. Others suggested that a strategy for addressing airflow issues be circulated to the community, and that instrument PIs be intimately involved in the modeling and verification process. Most of the responses, however, simply stressed the importance of an airflow modeling effort at ATD. Some of these are given below:

"These analyses are so important!"
"I commend those in ATD and the community who have worked on this in the past and who are pushing for a more systematic approach to addressing these problems in the future".
"More comprehensive airflow modeling for all of the aircraft in the research fleet will be a big plus".
"This is a very important effort and I hope that it doesn't get under funded and pushed to the side as it has in the past."
"NCAR ATD/RAF should be fluent in CFD modeling."
"This CFD effort has long been missing! I'm very excited that you wish to do this both with HIAPER and the C-130!"
"It will be even more important with HIAPER that we can quantify the impact of sampling at various locations. Having a facility let people get some model runs for their instrument would really be valuable for many of us."